TF 2150

Variable D.C. Power Supply

INSTRUCTION MANUAL

MP MASTER
MA23647

MARCONI INSTRUMENTS LIMITED

INSTRUCTION MANUAL
No. EB 2150

for

Variable D.C. Power Supply
TF 2150

MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND

M.I. 3.5c
6/71

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Chapter 1

General information

1.1 INTRODUCTION

The TF 2150 Power Supply, with a basic range of 0 to 20 V and 0 to 1 A, has been designed to meet the demand for a high performance, miniature regulated unit, with continuous control of both current and voltage.

TF 2150 is a variable power supply for the bench, the maximum output voltage being variable over the range 0-30 V, and the maximum output current limit variable over the range 0-1¼ A. This current output limit is such that if the load impedance is reduced sufficiently so as to tend to increase the output current beyond this, the supply becomes a constant current supply, the current being determined by the limit control. Thus TF 2150 can be used as a constant voltage or as a constant current supply.

The unit may be remotely programmed (by an external resistor) and the output may be grounded or floating. Two or more TF 2150's may be used in series or parallel to give a greater voltage or current capability.

1.2 DATA SUMMARY

1.2.1 Output

Maximum Output	25W
Maximum Continuous Output	20W
Maximum Voltage	30V
Maximum Current	1.25A
Regulation	Line: 1 mV + 0.03% for + 20V a.c. change Load: - (2 mV + 0.05%) zero to full load
Ripple	Less than 400 μV peak to peak
Response to Changes in Load	Recovers to within 50 mV in 50 μS
Temperature Co-efficient	-(3 mV + 0.02%) per °C
Internal Impedance	10 mΩ at 1 KHz

1.2.2 Current Limit

Continuously variable 0.04 - 1.2A
(0 - 0.04A by external circuit)

1.2.3 Voltage Control

Continuously variable 0.2 - 30V
(0 - 0.2V by external circuit)

Calibration Accuracy ± 2% of full scale

1.2.4	Power Requirements	105 - 125V a.c. or 210 - 250 V a.c. 50 - 60 Hz

1.2.5 Size and Weight

Width	Height	Depth	Weight
165 mm ($6\frac{1}{2}$ in)	83 mm ($3\frac{1}{4}$ in)	185 mm ($7\frac{1}{4}$ in)	2.3 kg (5 lb)

Chapter 2

Operation

2.1 MAINS - VOLTAGE SETTING

Before a mains supply is connected to the instrument, check that the tapping selected on the internal mains transformer is suitable for the supply voltage.

To gain access to the transformer, remove the case which is secured by four screws. The transformer is mounted at the right hand rear corner of the instrument, behind the meter.

Connections should be made as follows (refer to the diagram below and the power supply illustration on the last page).

Connection	110-115V	210-230V	230-250V
Black lead into Mains Cable	E	E	E
Black lead into Internal Cableform	A	A	A
Link	A to C and B to E	B to D	B to C

2.2 POWER PLUG

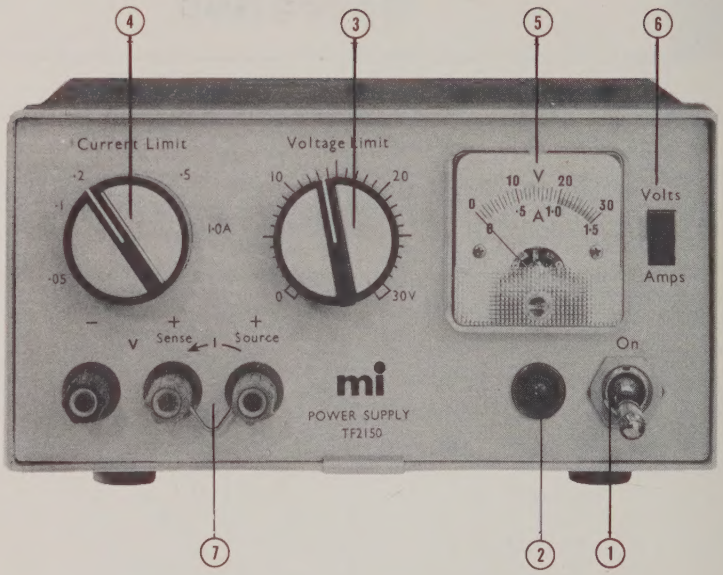
A suitable power plug must be fitted to the instrument power cable. The wires are colour coded as follows:-

Red or Brown	=	Mains Live
Black or Blue	=	Mains Neutral
Green or Yellow and Green	=	Earth

2.3 NORMAL OPERATION

For normal operation the positive source and positive sense terminals are joined together using the link provided. The controls then function as follows (refer to Fig. 1):-

Fig. 1. Controls.



(1) SUPPLY ON/OFF SWITCH

(2) SUPPLY INDICATION LAMP

(3) VOLTAGE LIMIT. This control adjusts the output voltage. This voltage is maintained until the current limit is reached.

(4) CURRENT LIMIT. This control determines the maximum current that may be drawn from the output terminals.

(5) METER. Monitors either the output voltage or output current, depending on the setting of the Meter Switch (6).

(6) METER SWITCH. Selects voltage or current meter ranges.

(7) OUTPUT TERMINALS. For normal operation the positive sense and positive source terminals are joined by a link.

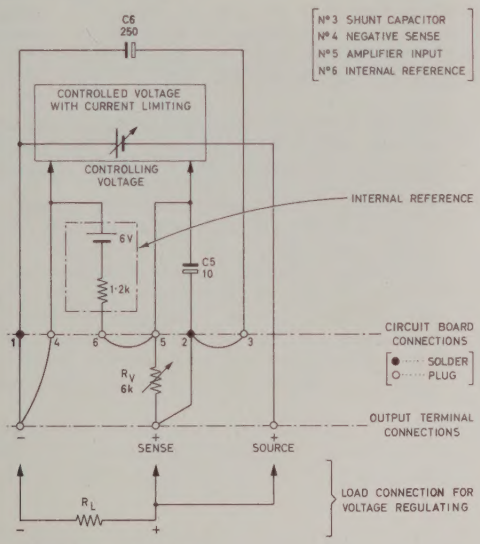
2.4 USE OF INTERNAL PLUG CONNECTIONS

2.4.1 Introduction

In order to provide flexibility for a variety of applications, there are, in addition to the three front panel output terminals, four plug connections on the printed circuit board. These can be reached by removing the small panel on the underside of the instrument case. The connections

are designated Nos. 3-6 inclusive and the number of the connection is marked on the printed circuit board. The connections to the terminals and the circuit board are indicated in the simplified diagram (refer to Fig.2):-

Fig. 2. Simplified Block Diagram.



2.4.2 **Output Terminal Connections.**

The controlled source delivers power to the negative and positive source terminals. For normal internal connections the controlled source tends to maintain a constant voltage between the negative and positive sense terminals. The value of this constant voltage is determined by the setting of the front panel voltage control. For normal voltage regulation the positive source and positive sense terminals are connected together with a shorting link and form the positive output terminal, as indicated.

There is a current limiting circuit which limits the current from the controlled source. Current limiting will occur when the current out of the positive source binding post tends to exceed the setting of the front panel current limit control.

2.4.3 Circuit Board Plug Connections.

No. 3. This connects a 250 μF capacitor across the output of the supply. It must be present to prevent oscillation in the supply and to provide low output impedance at high frequencies. It can be removed for fast response when operating with current limiting.

No. 4. This is the negative sense connection. When the negative lead wire to the load has a significant voltage drop regulation is adversely affected. A separate lead can be run directly from the negative terminal of the load to No. 4 on the circuit board to minimize this effect. This

extra lead carries only a few milliamperes and will not affect the regulation. The voltage drop between the minus terminal and No. 4 should be less than about 0.3 volts for good regulation.

No. 5. This connection is used for remote programming. If an external voltage control resistor is used it should be connected between positive sense and No. 5. The regulating voltage is approximately $V = 0.2 + .005R$ (units of volts, ohms, and amps) where R is the total resistance between positive sense and No. 5.

No. 6. This connects to the internal zener diode reference circuit, signified by the 6V battery and 1.2 KΩ resistor in the diagram. If it is desirable to use an external reference, No. 6 can be disconnected.

Chapter 3

Circuit description

Reference should be made to Fig.3 - Circuit Diagram - which is sub-divided into six sub-circuits, each of which is described below.

3.1 TRANSFORMER AND RECTIFIER-FILTER (CIRCUIT 1).

The transformer, T1, converts 240 volts, 50 Hz into 24 volts, 50 Hz. The lower secondary a.c. voltage is then converted to positive and negative 30 volts d.c. by two half-wave rectifiers, MR1 and MR2 with capacitor filters, C2 and C3. The positive supply provides the main voltage output, across C2, while the negative supply provides voltage for the reference circuit across C3. The exact value of the rectifier output voltages varies between 23V and 38V depending on the line voltage, the load current and the transformer temperature. The a.c. ripple, superimposed on the d.c. voltage, will also vary considerably but typically it is a 50 Hz sawtooth waveform with a magnitude of 1 to 3 volts peak to peak.

A third diode, MR4, is in series with the +30 volt output and provides about 0.6 volt bias for the power transistor circuit. Note that diodes MR1, MR4 (and MR8) are high current diodes mounted on a bracket attached to the transformer.

The thermal cutout, THT1, is mounted on the rear panel heat sink. It opens if the heat sink temperature exceeds about 65°C, and recloses when the temperature drops to about 54°C. The neon pilot lamp, Ne1, indicates when a.c. is applied to the transformer and will thus signal operation of the thermal cutout. The switch, S1, is the panel on-off switch. The 2.5 amp fuse in series with this switch is mounted on the rear panel. It protects most of the components in the power supply against excessive line voltage or against failure of some one component in the circuit. The fuse will normally burn out only if some component in the power supply fails or if improper internal connections are made.

3.2 REFERENCE CIRCUIT (CIRCUIT 2).

A stable reference voltage is derived from the -30 volt supply by a cascade of two regulator circuits. The first circuit consists of R5, R6, MR6 and VT4 and causes the collector current of VT4 to be very nearly constant (about 10 mA) and independent of line voltage and temperature.

Although the VT4 collector current is relatively constant, it is nevertheless, subject to variations of the order of ±0.1% with line voltage changes of ±10% or temperature changes of ±2°C. To provide better regulation, a second zener diode, MR7, is used to reduce variations even further. The 50 Hz component of voltage across MR7 is less than 50 μV peak to peak.

R14 is a low-drift temperature compensated resistor. RV2 is a small wirewound trimmer resistor, (mounted on the printed circuit board) which is used to calibrate the voltage control. The calibration control is necessary

because of the unit-to-unit variations in zener voltage of MR7 and in resistors R14 and RV3. When the supply is properly calibrated and operating in the voltage regulating mode, the current through RV3 is 5 mA ± 3% and varies less than ±.02% with a ± 10% change in line voltage, a 1A change in load current, or a ± 1°C change in temperature.

3.3 VOLTAGE REGULATING AMPLIFIER (CIRCUIT 3).

This is a three-stage amplifier employing a common emitter stage, VT6, driving a common collector stage, VT5, which drives a second common emitter stage, VT3. Resistor R13 is used to limit input current to a safe value under the worst case condition of RV3 = 0 and a +30 volt source connected across the output. Resistor R7 limits the current in VT3 when the circuit is operating in the current limiting mode with VT3 saturated.

A resistor, R4, and a zener diode, MR5 are used to create a constant +9 volt supply which provides bias power for the first two stages. The zener diode is necessary to prevent changes in voltage across C2 from producing changes in the operating point of VT6, which would, in turn, produce changes in power supply output voltage. R4 also limits the current in VT5 when the power supply is in the current limiting mode.

Note that a special negative sense lead connects directly from the negative output terminal to the emitter of VT6 and the positive side of MR7. This sense lead establishes a zero-voltage reference at the negative output terminal and prevents internal lead resistance, between circuit board and binding post from adversely affecting regulation. This internal lead resistance is typically 5 milliohms and would decrease the load regulation by about a factor of two. As described in part 2.4.3, the negative sense lead can also be connected directly to a remote load terminal in order to negate any deterioration of regulation caused by external lead resistance. However, for proper operation of the regulating amplifier, the voltage of this negative sense lead should not differ from the negative output terminal voltage by more than about ± 0.3 volts.

R11 and C4 provide high frequency feed-back within the regulating amplifier. This helps prevent oscillations that would otherwise be caused by the large amount of overall feed-back through C5.

3.4 SERIES REGULATOR AND METER (CIRCUIT 4).

The series regulator is a germanium transistor connected in series between the rectifier output and the positive output terminal. The base current is controlled by either Circuit 3 or 5. This transistor behaves essentially as an electronically controlled variable resistor. Since it must dissipate several watts of power it is a power transistor and is mounted on a rear panel heat sink. This heat sink is convection cooled. The maximum possible dissipation of 32 watts occurs for high line voltage, high load current, and low load voltage. The transistor can safely dissipate this amount of power with a collector junction temperature of 92°C, a heat sink temperature of 60°C and an ambient temperature of 20°C. For operation at higher ambient temperatures, however, the transistor would be damaged by excessive junction temperatures, so a thermal cutout is used as described in Chapter 3.1.

Diode MR8 serves a purely protective purpose and is normally reverse biased. If, however, a reverse polarity voltage is connected across the output of the power supply, then this diode will conduct and prevent damage to transistors VT6 and VT2 and capacitors C6 and C5. This type of reverse voltage situation will commonly arise if two or more power supplies are connected in series to provide higher output voltage than can be achieved with a single supply. If one series supply is off and another one on, then the on supply load current flows through the load and through MR8 in the off supply; without MR8 the output terminals would be reverse biased.

The meter is either connected in parallel with R10 to measure current, or in series with R12 to measure voltage. Note that when switch S2 is in the current metering position and the power supply is in the voltage regulating mode, the ammeter reads 5 mA more than the actual load current because of the 5 mA current in RV3. This 5 mA produces a discernible but negligible deflection on the meter.

3.5 CURRENT LIMITING AMPLIFIER (CIRCUIT 5).

Current limiting is accomplished by a single transistor, VT1, driving the same series regulator transistor which is used for voltage regulation. The properties of VT1 and MR3 are such that the voltage across RV1 + R3 is approximately (.85 - .005T) volts where T is the temperature, in °C, of VT1 and MR3. Assuming that I out is approximately equal to the current through RV1 + R3, we have:

$$I_{out} \approx \frac{.85 - .005T}{R3 + RV1}$$

The temperature dependence indicated in the above equation also decreases the maximum output current at high temperature and affords extra protection against excess dissipation in VT2.

The current limiting control, RV1, is a wirewound rheostat with a non-linear resistance versus rotation characteristic. This non-linear characteristic allows a wide range of control over the current limiting, as indicated by the panel calibration. Resistor R1 allows the base of VT2 to be reverse biased for operation at high temperatures. It also helps turn VT2 off more quickly if the load current is suddenly reduced.

3.6 FEEDBACK CIRCUIT (CIRCUIT 6).

The input voltage to VT6 is very nearly constant with V in ≈ 0.2 volts. Also, I in is less than 20 microamperes when the supply is in the regulating mode. Thus virtually the only current in the voltage control, RV3, is the 5 milliamps from the reference current source. It should be evident from the circuit diagram of section 7 that if we neglect I in we can use Kirchoff's laws to write:

$$V_{out} = V_{in} + (.005) \times (RV3) = 0.2 + \frac{RV3}{200}$$

(V measured in volts and RV3 in ohms)

Capacitor C5 serves two important functions. Primarily it maintains a low output impedance at high frequencies, where the regulating circuit becomes ineffective, and it helps to prevent voltage transients when the load is suddenly removed. For example, the power transistor requires about 20 microseconds to turn-off and C6 absorbs the power transistor current during this period of time. C6 also helps to prevent high frequency oscillation in the regulating circuit.

Capacitor C6 provides increased feedback for frequencies above about 30 Hz and thereby reduces the a.c. output impedance and the 50 Hz ripple and noise in the output.

Chapter 4

Replaceable parts

4.1 ORDERING INFORMATION.

When ordering spare parts quote the M. I. FPP Part No., plus the instrument type number, e.g., TF 2150/FPP/A/5024/12/1.

Orders may be placed via a Marconi Instruments Distributor, or direct to:-

Marconi Instruments Ltd.,
Service Division,
Hedley Road,
St. Albans,
Hertfordshire, England.

Spares supplied against Marconi Parts Numbers are electrically interchangeable with those originally fitted, but may not always be identical.

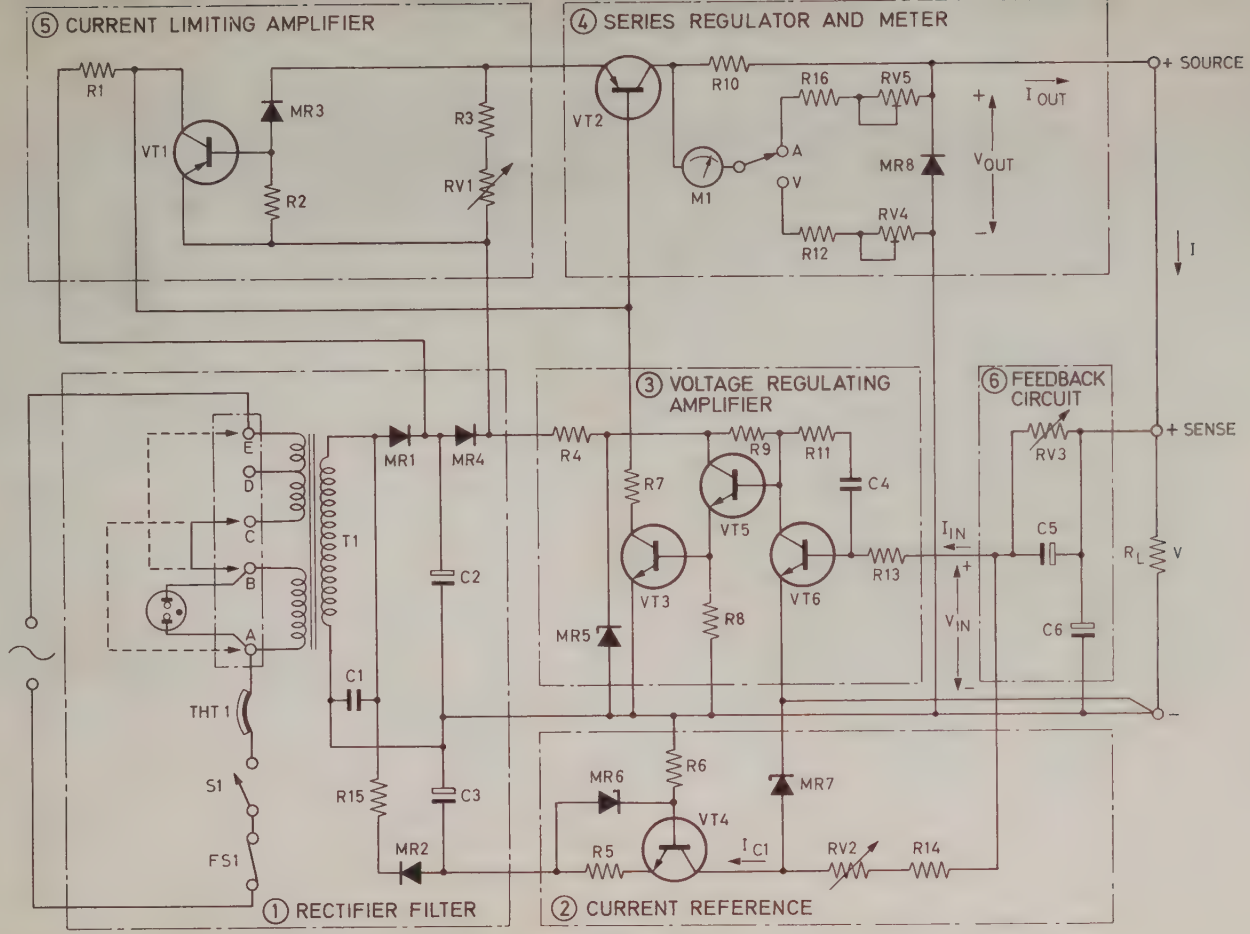
4.2 PARTS LIST

The following list includes all replacement parts with circuit references, values and tolerance, where applicable, and part numbers.

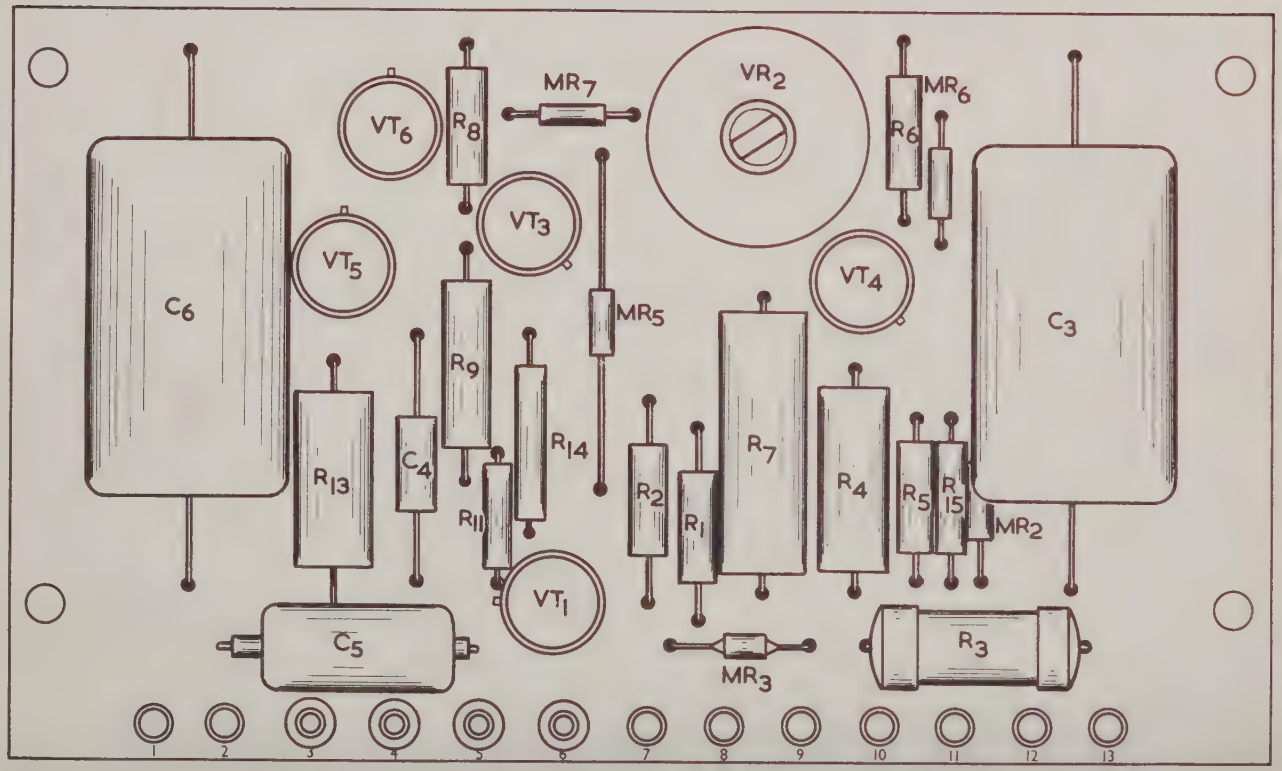
Circuit Ref.	Value	Description	Marconi Part No. TF 2150 FPP/
Transistors			
VT1 Transistor		2N1305	A/5024/12/1
VT2 Transistor		2N1545	A/5024/12/2
VT3 Transistor		2N696	A/5024/12/3
VT4 Transistor		2N696	A/5024/12/3
VT5 Transistor		2N1304	A/5024/12/4
VT6 Transistor		2N1304	A/5024/12/4
Diodes			
MR1 Diode		BYX38-300	A/5024/12/5
MR2 Diode		OA202 Mullard	A/5024/12/6
MR3 Diode		OA202 Mullard	A/5024/12/6
MR4 Diode		BYX38-300	A/5024/12/5
MR5 Zener Diode	9.1V	BZY88C9V1)	A/5024/12/7
MR6 Zener Diode	12V	BZY94C12)Mullard	A/5024/12/8
MR7 Zener Diode	6.2V	BZY88C6V2)	A/5024/12/9
MR8 Diode		BYX38-300	A/5024/12/5

PARTS LIST (continued).

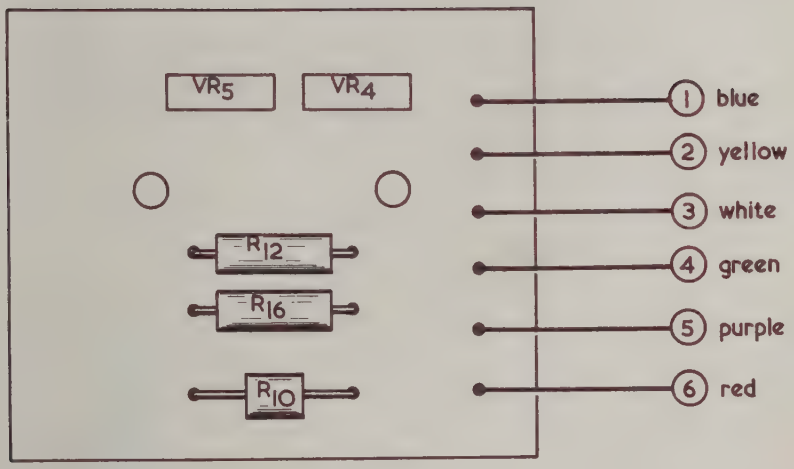
Circuit Ref.		Value	Description	Marconi Part No. TF 2150 FPP/
Transformers				
T1	Transformer		B5024/1 Weir	A/5024/12/10
Resistors				
R1	Resistor H.S.	100 ohms ½W 5%	WP051 Waycom	A/5024/12/12
R2	Resistor H.S.	330 ohms ½W 5%	WP051 Waycom	A/5024/12/13
R3	Resistor W.W.	0.6 ohms 1W 1%	AW3214 Welwyn	A/5024/12/14
R4	Resistor H.S.	1.5K ohms 1W 5%	WP11 Waycom	A/5024/12/15
R5	Resistor H.S.	1.2K ohms ½W 5%	WP051 Waycom	A/5024/12/16
R6	Resistor H.S.	4.7K ohms ½W 5%	WP051 Waycom	A/5024/12/17
R7	Resistor H.S.	680 ohms 2W 5%	WP22 Waycom	A/5024/12/18
R8	Resistor H.S.	1K ohms ½W 5%	WP051 Waycom	A/5024/12/19
R9	Resistor H.S.	4.7K ohms ½W 2%	TR6 Electrosil	A/5024/12/20
R10	Resistor W.W.	0.5 ohms 3W 10%	Radio Resistor Co.	A/5024/12/21
R11	Resistor H.S.	10K ohms ½W 5%	WP051 Waycom	A/5024/12/22
R12	Resistor H.S.	27K ohms ½W 5%	WP051 Waycom	A/5024/12/23
R13	Resistor H.S.	1K ohms 1W 5%	WP11 Waycom	A/5024/12/24
R14	Resistor H.S.	1K ohms ½W 2%	TR6 Electrosil	A/5024/12/25
R15	Resistor H.S.	47 ohms ½W 5%	WP051 Waycom	A/5024/12/26
R16	Resistor H.S.	470 ohms ½W 5%	WP051 Waycom	A/5024/12/27
Variable Resistors				
RV1	Variable Resistor	25 ohms Special Law		A/5024/12/28
RV2	Variable Resistor	500 ohms		A/5024/12/30
RV3	Variable Resistor	6K ohms		A/5024/12/31
RV4	Variable Resistor	5K ohms		A/5024/12/32
RV5	Variable Resistor	500 ohms		A/5024/12/33
Capacitors				
C1	Capacitor	.01 MFD 250V	SLM13 Hunts	A/5024/12/34
C2	Capacitor	5600 MFD 50V	C432 FR/G 5600 Mullard	A/5024/12/35
C3	Capacitor	250 MFD 65V	C437/AR/H250 Mullard	A/5024/12/36
C4	Capacitor	.001 MFD 500V	SLM32 Hunts	A/5024/12/37
C5	Capacitor	10 MFD 65V	C426/AR/H10 Mullard	A/5024/12/38
C6	Capacitor	250 MFD 65V	Hunts MEFAST	A/5024/12/36
S1	Switch		T953	A/5024/12/39
S2	Switch		T220	A/5024/12/40
THT1	Thermostat		A/5024/24	A/5024/12/41
Ne1	Lamp, Neon		SGF9/A/110/Red Thorn	A/5024/12/42
M1	Meter	0-1 mA	MR2P	A/5024/12/43
FS1	Fuse	2.5A Size 00		A/5024/12/44



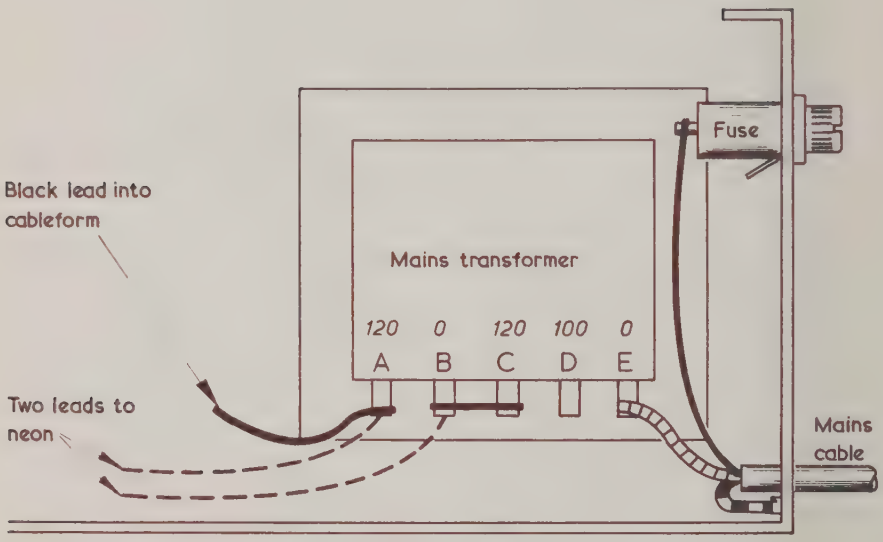
CIRCUIT DIAGRAM



MAIN COMPONENT BOARD LAYOUT



SUBSIDIARY BOARD LAYOUT



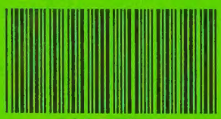
Shown connected for *230 - 250 V* A.C. operation

POWER SUPPLY CONNECTIONS

MARCONI INSTRUMENTS LIMITED
ST. ALBANS, HERTS., ENGLAND

SERVICE DIVISION	THE AIRPORT, LUTON, BEDS. LU2 9NS *Telephone: Luton 33866*
HOME and EXPORT SALES OFFICES	LONGACRES, ST. ALBANS, HERTS. *Telephone: St. Albans 59292* *Telegrams: Measurtest, St. Albans* *Telex: 23350*
U.S.A.	MARCONI INSTRUMENTS DIVISION OF ENGLISH ELECTRIC CORP., 111 CEDAR LANE, ENGLEWOOD, NEW JERSEY 07631 *Telephone: 201 567-0607*
BUNDESREPUBLIC DEUTSCHLAND	MARCONI MESSTECHNIK G.M.B.H. P.O. BOX NO. 210330 JOERGSTRASSE 74 8000 MUNICH 21 *Telephones: 58.32.97; 58.42.05; 58.61.56* *Telex: 524642*
FRANCE	MARCONI INSTRUMENTS SUCCURSALE DE FRANCE 32 AVENUE DES ECOLES 91 SAVIGNY SUR ORGE *Telephone: 921.69.93*

MP MASTER



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RLD-WIDE REPRESENTATION

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